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Fifth day of January 2004

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Automated Pallet Inspection and Repair

Field of the Invention

The invention pertains to pallet repair and more particularly to the automated inspection and repair of pallets, especially timber pallets. It will be appreciated that the teachings of the present invention may be extended to a variety of pallet styles. It will also be appreciated that the inspection and various repair devices and methods disclosed below are capable of separate use each having utility without the other, but being particularly useful when used in any of various combinations.

Background of the Invention

Timber pallets may be constructed in two basic styles, the first being made up of three (or more) bearers or stringers, with boards running across the top and bottom of these to make up a deck for supporting products. Boards are generally nailed on to the bearers, but may be screwed on or attached by other methods. The second style is similar but has blocks and connector boards in place of the bearers. Pallets of both styles may be constructed in a variety of sizes depending on their use and geographic location. Pallets may also be constructed in other materials, such as plastic, metal, composite materials or a combination of materials.

Pallets (of any style) can be repaired when damaged. This repair traditionally requires manual handling and inspection by an operator, with mechanised systems available for moving the pallet to and from the human operator. Additionally, there is sometimes a separate requirement for pallets (of any style) to be inspected against standards and quality criteria to determine that they are fit for use – this is also currently a manual process.

Objects and Summary of the Invention

It is an object of the invention to provide devices and methods for the automated inspection and repair of wooden pallets.

Accordingly, the invention provides various devices and methods for the automated inspection and repair of pallets. In preferred embodiments, a pallet is retained by a gripping device which remains with the pallet during inspection and at least one subsequent repair operation.

Brief Description of the Drawing Figures

In order that the invention is better understood, reference is now made to the following drawing figures in which:

Figure 1 is a perspective view of an automated inspection table;
Figure 2 is a perspective view of a pallet inspection and repair cell having various stations;
Figure 3 is a perspective view of another pallet gripping device;
Figure 4 is a perspective view of an alternate pallet gripping device; and
Figure 5 is a perspective view of a further pallet gripping device.

Best Mode and Other Embodiments of the Invention

As shown in Figure 1, an automated inspection table 10 may be used in a stand-alone capacity without the associated repair system as a quality control system or sorting system. As a quality control system it could be used to determine whether pallets are fit for use (i.e. meet the quality standard for that style of pallet). As a sorting system it could be used to gather data for sorting pallets by type, size, or quality level. Various repair

devices and methods are disclosed below. These may be used alone or in combination after either a manual or automatic inspection.

The sensing table 10 includes a frame 11 which supports a pallet supporting surface 12. The pallet supporting surface may take various forms. In one form the supporting surface is a motorised conveyor which is capable of propelling a pallet past a sensing head so that data about the physical properties of the pallet may be obtained.

A pallet feature sensing head may be constructed in different styles. Firstly it may be constructed with a series of sensors in a line (linear array) to detect the presence or absence of timber (or other pallet material). This type of sensing head would be positioned adjacent to the moving pallet so that it scans the pallet surface passing near it. Such a sensing head would give a two dimensional image or map of pallet characteristic values. The values may be digital. This image can then be analysed against a set criteria with the identified differences used as a criteria of pallet quality.

The alternative method of construction for the sensing head is to use a laser and camera system 13 to capture individual profiles (cross sections) of the pallet (i.e. the camera records the location of a projected laser line and triangulates its position to give height and coordinate data). The laser beam which is projected onto the pallet may be fan shaped or it may be scanned across the pallet surface using, for example, moving mirrors. Such a system will provide three-dimensional data on the pallet and can be used for detecting gaps or protrusions such as nails, hanging plastic etc. The three dimensional data can be filtered into a two dimensional image of on/off values by using a dynamically created height value, corresponding to a reference plane or set threshold offset above the bearer or connector board surface. Points in the profiles above this threshold plane are set to "on" in the two dimensional representation, points below are set to "off". The three dimensional data can also be filtered using image analysis algorithms (such as the Sobel or Gaussian filters) to provide locations of protrusions, cracks and other deviations in the pallet element surfaces.

In other embodiments of the automated inspection table 10, a conveying surface 12 is not needed. Instead the pallet is gripped with an appliance or device and then pulled or pushed through the frame adjacent to the linear array or laser device 13.

Data in the two dimensional form noted above is sorted into arrays of related points representing each pallet element such as a board, broken board segment, bearer etc. Each element array is then tested against a range of criteria to determine the quality of that element, and whether a pallet component should be removed or adjusted. In addition, gaps between components or elements are also tested against a range of criteria to determine whether neighbouring pallet elements should be marked for inspection. Decisions made for each element or gap are made in a hierarchical manner – e.g. element removal decisions override element position adjust decisions and so on. When all checks on a particular element have been made, the highest-ranking decision for that element is recorded to a database. Overall pallet analysis is carried out once all elements have been checked and decisions stored to the database. This overall analysis can be used to sort pallets into various styles (eg by number of boards) or into good and bad (eg by number of operations required on pallet), alternatively it can be used to determine whether the pallet is able to be repaired by an automated system or must be sent to a human operator for inspection.

As shown in Figure 2, a pallet will arrive at an inspection and repair cell 20, by any means (eg forklift, conveyor, pallet dispenser). In this embodiment, pallets arrive on a top input conveyor 21 which is in effect the first station of the automated cell 20. This repair cell may take a number of configurations but in this particular embodiment the cell is essentially a continuous circuit which begins on the top input conveyor 21 and ends on the bottom output conveyor 22. When the pallet has arrived at the cell it must be gripped before further operations to take place. Gripping is accomplished with a robotic style arm 23 which is equipped with a machine detectable reference point (or datum) 24 and a gripping device or appliance 25. The gripping appliance 25 may have its own datum 26, which in some embodiments is the only datum.

Gripping the pallet throughout the automated inspection and repair process has several advantages. First, gripping the pallet such that all elements of the pallet are, from that point onward, in a fixed location relative to at least one datum provides a convenient way of locating the pallet and its features, in space, throughout the entire inspection and repair process or circuit. This allows the pallet to be mapped and the pallet's features to be recorded to, for example, a database. Control over the inspection and repair process is possible because each recordable feature has a reference to a datum which can be read, whenever required, to locate the pallet relative to a particular workstation, inspection station, or repair station. Second, gripping provides a secure way of handling the pallet, making both sides of the pallet potentially accessible in a way which does not interfere with either inspection or repair.

As shown for example in Figures 3,4 and 5, pallet gripping may take place in a number of ways – firstly a gripper 25 having compressing grips 28 may be inserted between the bearers 26 for the purpose of clamping the central bearer 27 or central blocks. Alternatively and as shown in Figure 5 a tensile gripper 50 may be inserted between the bearers 51 and expand outward to clamp against the inside edges of the outermost bearers or blocks 51. Alternately, if inserted into the pallet 52, the gripper may expand against the inner faces 53 of the top and bottom deck boards. As shown in Figure 4, the gripper may take the form of a large rectangular hoop or frame 40, which may be placed around the entire pallet. Such a hoop or frame would then be reduced in size to clamp the pallet securely around its periphery. Size reduction of the hoop or frame could be achieved with pneumatic or hydraulic cylinders 41 attached together by an end piece 42. The terminal ends 43 of the arms 41 need not be attached to one another. Alternatively the gripper may be a hybrid between these cases.

In all cases, the gripper must be small and thin enough to not impede access to the deck boards on the pallet, however it must be strong enough to hold the pallet against high inertial forces when moved between sections of the repair cell. The gripper may have sensing devices installed to check that a pallet has been successfully gripped. For example, Figure 5 shows sensors 55 which sense the presence or proximity of the inside

surface of the adjacent bearer, thus confirming proper contact has been made. The sensors may be provided on all required pallet contacting surfaces. In the example of Figure 5, the contact sensors 55 extend along the exterior contacting surfaces 56. One or more sensors 55a are located in a position corresponding to the closest portion, front opening or mouth of the pallet 57. When this sensor 55a is activated, it confirms that the gripper is fully inserted in the pallet. This concept is extendible to other gripper styles.

The gripper or gripping device may include a wrist joint or coupling 45, for example as shown in Figure 4. In other embodiments the gripping device does not include a wrist joint or coupling. In either event the gripping device, if detachable, must have a locking mechanism so that it stays closed and gripping even when disconnected from the arm which manipulates it.

The gripper is attached to a manipulating device such as a robotic arm that can move the gripped pallet through space in any direction and at any angle. This may be a multi-axis robotic arm (23 in Figure 1), or any device for translating and rotating the gripped pallet. The robot arm or manipulating device may be fixed or on rails or tracks. It may be vertical or horizontal or at any angle, and may be attached to the walls, a pedestal, the floor, ceiling, overhead or suspended structures or a combination of these. The gripper may be permanently attached to the manipulating device, or it may be able to detach and reattach at various points in the repair cell if needed, to allow the manipulating device to work with multiple pallets.

In the example of Figure 2, the robotic arm 23 is capable of manipulating the gripped pallet through a rotational process circuit comprising, input conveyor 21, inspection station 10, lead board adjustment station 60, board removal station 70, new board installation station 80 and finally and output conveyor 22. In this example the overall movement of the pallet is clockwise (viewed from above) through the circuit which the cell performs.

As suggested above, the gripper e.g.25 secures the pallet, and draws it through an automatic pallet inspection table 10. In preferred embodiments the pallet (and at least one datum from the gripper or arm) is passed through the inspection system at a known constant (or measurable and recordable) velocity, at a consistent and known distance from the camera or sensors in the inspection system 10. This system will then compile the data about the pallet into a database for use by the other equipment in the cell. This is a form of mapping of features relative to a datum. Data acquired in this way may include the location of protruding nails or other objects, the location of cracks, the location of cracked boards, or misaligned boards or missing boards. Alternatively, an input screen could be provided for an operator to manually or semi-automatically enter the details of the damage to the pallet, and this data would be stored in the database in place of the automatic inspection system data.

If a horizontal conveyor is used that has the pallet running above the conveyor (attached to a gripper), then a break in the conveyor must be used to allow inspection of the bottom deck of the pallet. Alternatively if the pallet is hung from an overhead conveyor (attached to a gripper), a break must be used to allow inspection of the upper deck.

If the pallet requires the leading boards on the pallet to be adjusted into the correct position, the gripper, with or without the arm attached, must be moved to a machine 60 for the adjustment of boards. Such a machine will correct the position of the four leading boards (two top and two bottom leading boards) using hydraulics, pneumatics or other positioning type systems 61. When the board positions have been adjusted, the boards must be pressed such that the nails already in the board will hold it in place. This occurs with the gripper in place.

If a board or boards must be removed from the pallet (due to damage or contamination), the pallet and its gripper must be manoeuvred into position with a machine 70 for removing individual boards. Data for the position of this board will be in the database from the automated inspection system.

A machine for removing an individual board may take the form of a bandsaw blade, positioned in any orientation (orientation based on manipulating the gripped pallet into position). This blade would then be applied between the board to be removed and its neighbouring board by resting the blade on the top surface of the bearers, and then the manipulator would drive the pallet through the saw to cut the nails and remove the board. Alternatively, once it had positioned the pallet in relation to the saw, the manipulator could lock in position and the saw could move the required distance to cut off the damaged board.

Alternatively, a board could be pried off the pallet using a simple lever based device, where the manipulator would position the pallet with the board to be removed in line with a levered plate, and hydraulic, pneumatic or electric actuation would lever the plate pushing the board off. This is suited to pallets where there is insufficient space between damaged boards to insert a bandsaw blade. In either the bandsaw or board lever, the arm (or whatever device is holding the gripper) may be required to rotate the pallet such that either the top or bottom deck of the pallet is facing the machine.

If boards have been removed or were missing when inspected, boards will need to be placed on the pallet in the correct position. This will require the manipulating device to position the gripped pallet in a device 80 for placing boards onto the pallet. This device takes boards from stacks of boards and positions them on the pallet. It will then insert nails from a hopper 81 into the board to attach it to the bearer. This may be done hydraulically, pneumatically or via other mechanical means. If boards need to be replaced on both decks of the pallet, the manipulator must remove the gripper and pallet from the machine, rotate the pallet and gripper through 180 degrees and return it for the second operation. If boards were loose or were adjusted, the pallet will also be placed in this machine, where only the nailing function would be used.

After going through these machines, the pallet has been inspected and repaired, but may need cleaning to be fit for use. The manipulator will then guide the gripped

pallet through a decontamination unit (not shown) that would consist of rotating (or fixed) brushes with dust extraction and a washing system.

When the pallet has been through each of these machines, it will be fit for use. When it is fit for use, the manipulator will move the pallet to an outfeed conveyor section 22 of the cell, the gripper will disengage from the pallet and the pallet will be conveyed (by chain or roller or belt conveyor) away from the repair cell. Pallets may then proceed to a painting machine, if required. The gripper and manipulator will then return to the infeed section 21 of the cell to start the process again on the next pallet.

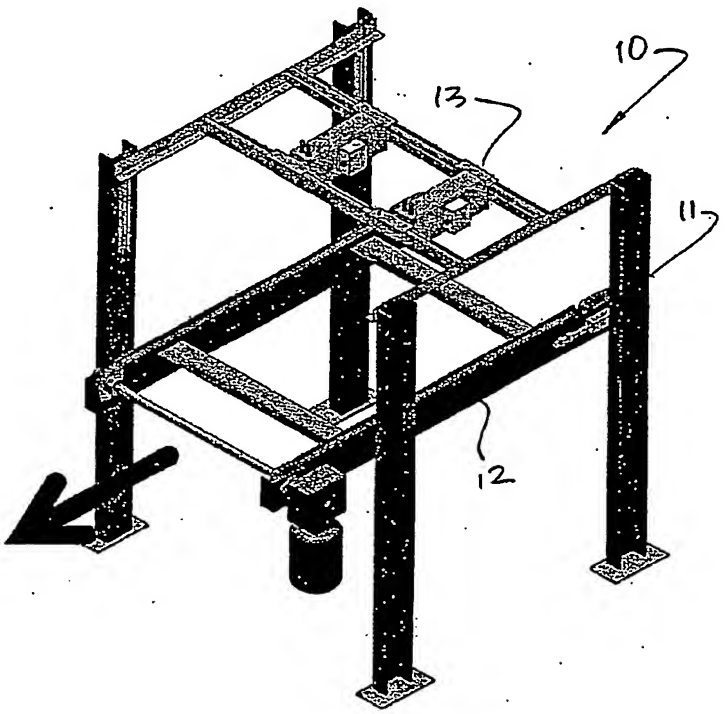

Fig. 1

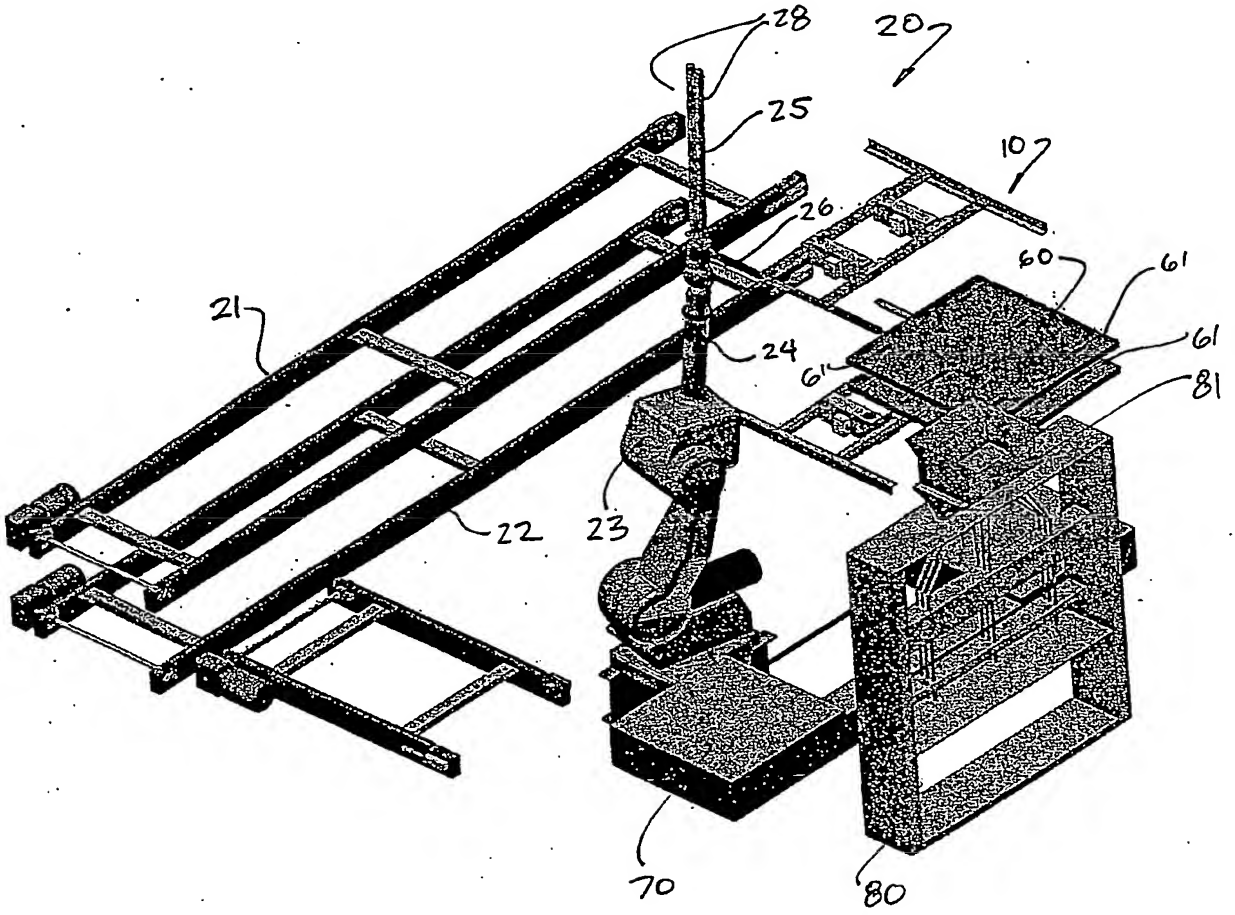

Fig. 2

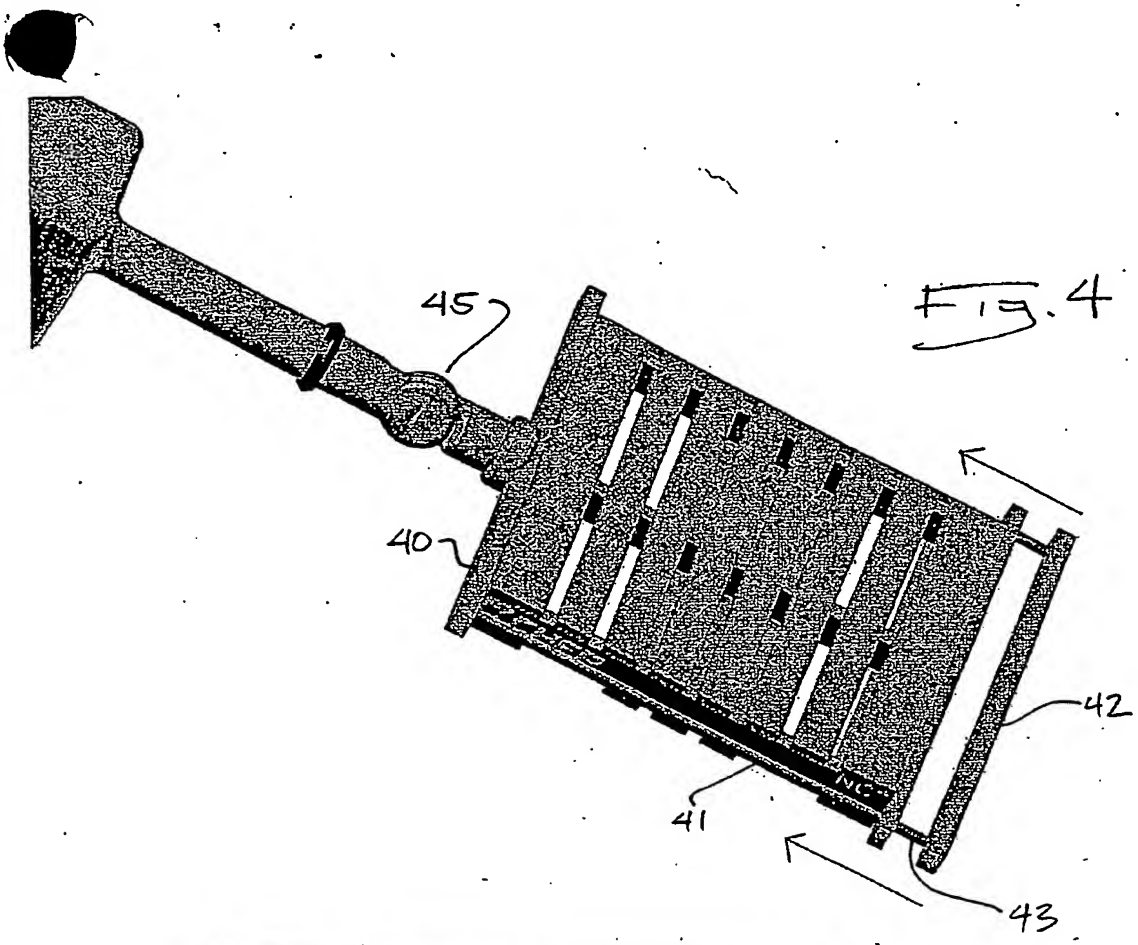

Fig. 4

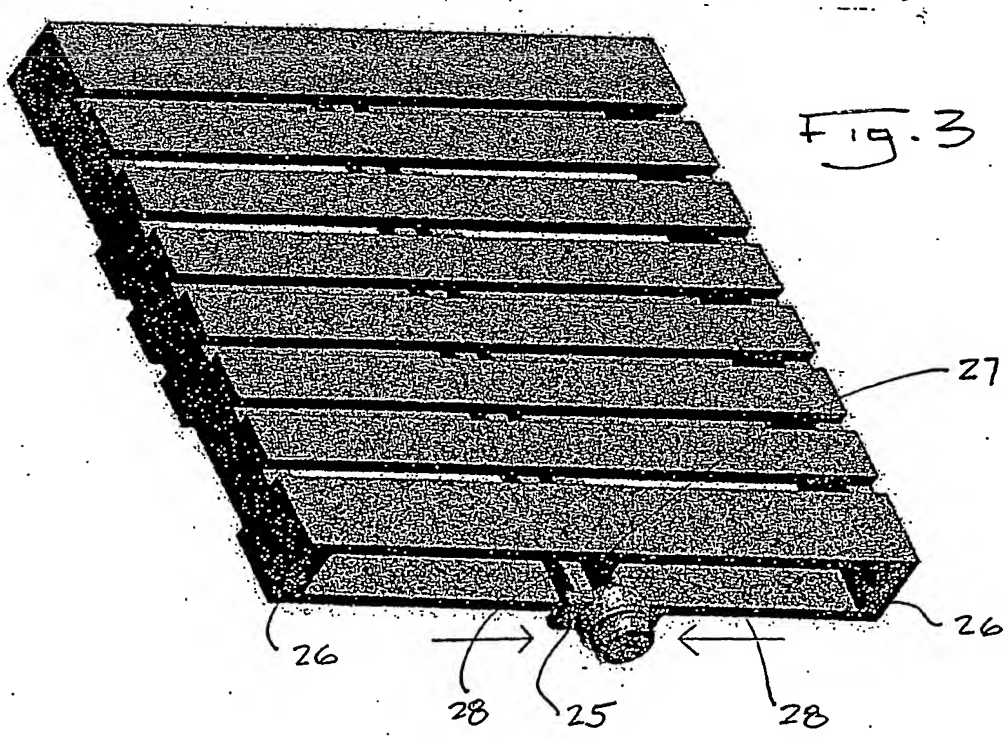

Fig. 3

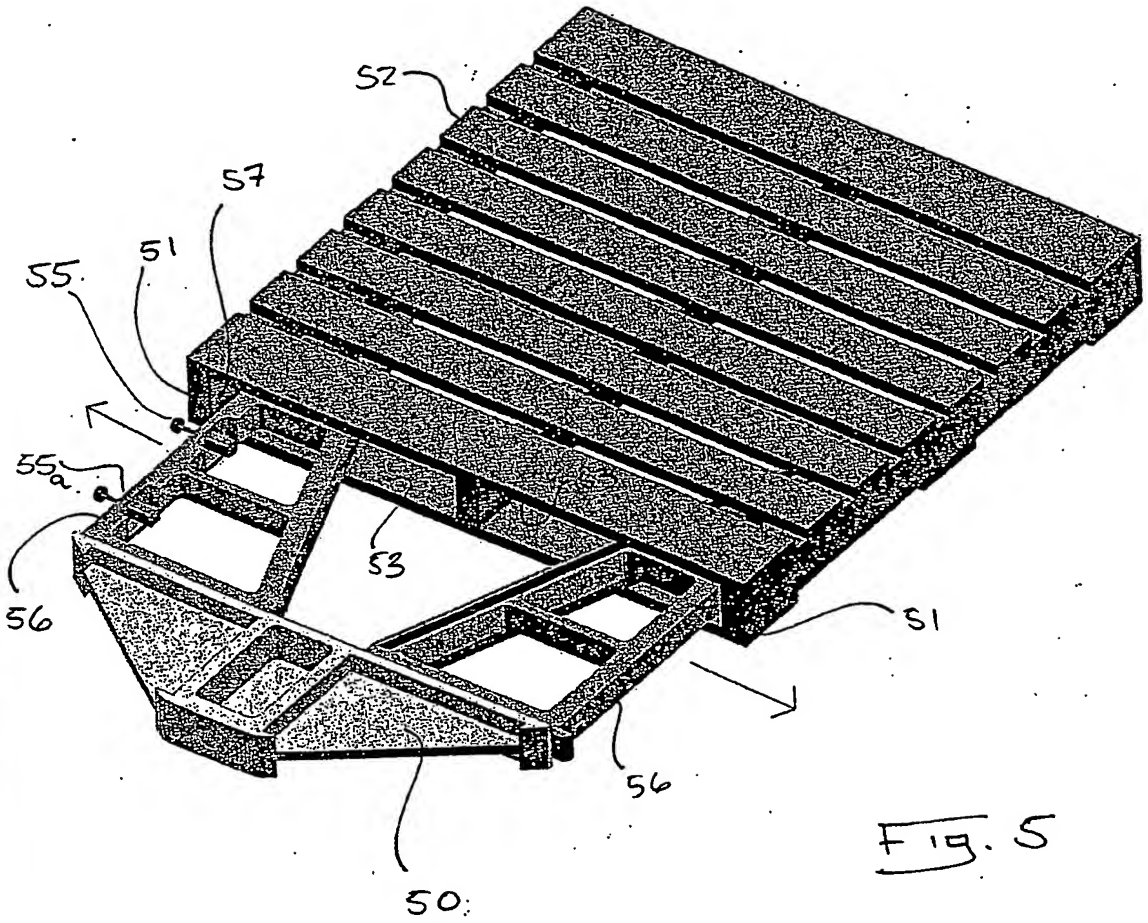

Fig. 5